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Preparing for Success in the Laboratory

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The Project	2
If You Don't Define the Project, the Project Will Define You	2
Which Research Style Best Fits Your Situation?	2
Do You Have the Essential Resources?	2
Expect the Unexpected	3
What If Things Go Better Than Expected?	4
When Has the Project Been Completed?	4
Was the Project a Success?	4
A Friendly Suggestion	4
The Research	5
Are Bad Data a Myth?	5
What Constitutes a Successful Outcome?	5
What Source of Data Would Be Most Compelling?	5
Do You Have the Expertise to Obtain These Types of Data?	5
What Can You Do to Maximize the Reliability of Your Data?	6
Are You on Schedule?	7
Which Variables Require Controls?	7
The Roles of Reporting	8
The Rewards	9
Bibliography	9

THE PROJECT

If You Don't Define the Project, the Project Will Define You

One of the first and toughest questions researchers must answer to foster success in the lab is: What do I have to accomplish? This requires you to understand your purpose to the larger task at hand. If your research is self-directed, the answer will most likely differ from that for someone working as part of a team effort or answering to an immediate supervisor or experimental designer. Ask them (or yourself) what the ultimate goals are and what constitutes a successful outcome. Establish what constitutes compelling evidence. By projecting ahead it becomes much easier to characterize the nature of the desired outcome.

This approach allows for problem reduction and reasonable task planning. The greatest mistake one can make is to react hastily to the pressures of the research by jumping in unprepared. By starting with the big picture, the stage is set for working backward and reducing what might otherwise appear to be a daunting undertaking into a series of reasonably achievable tasks. This exercise also establishes the criteria for making the many decisions that you will face during the course of your work.

Which Research Style Best Fits Your Situation?

Certain decisions will have a profound impact on the nature and quality of your efforts. Some scientists favor deliberate attention to detail, careful planning and execution of each experiment. Others emphasize taking risks, skipping ahead and plunging in for quick results. You might want to consider which approach would best satisfy your superior(s) and colleagues. Each of these "styles" has its benefits and risks, but a well-balanced approach takes advantage of each. Sometimes it is essential to obtain a quick answer to a question before committing a substantial amount of time to a more diligent data-collecting phase. Be sure everyone involved is in agreement and then plan your activities accordingly.

Do You Have the Essential Resources?

Evaluate your circumstances with a critical eye. Look at your schedule and that of your collaborators. Is everyone able to devote the time and energies this project will demand with a minimum of distractions? Check your facilities; do you have access to the materials and methods to do the job? Do you have the support

of the decision-makers and budget managers for the duration of the work?

Whether or not problems were uncovered, share your findings with your director and collaborators; the objective of this phase is to build a consensus to proceed with no further changes.

Expect the Unexpected

How flexible is your research plan? Have you allowed yourself the freedom to adapt your strategy in light of unanticipated outcomes? This happens frequently and is not always bad news. Unexpected results might require slowing down the process or stopping altogether until a new path can be selected. Perhaps whole elements of the work might be skipped. In any case you should plan on midcourse corrections in your schedule. You can't always eliminate these redirections, but if you plan for them, you can avoid many unnecessary surprises. There are likely to be multiple paths to the desired outcome. If the unexpected occurs, consider categorizing problems as either technical or global. Technical problems are usually procedural in nature. The data obtained are either unreliable or untenable. In the former case the gathering of data may need to be repeated or the procedure optimized to the new conditions in order to increase data reliability. In the later case the procedure may prove to be inadequate and an alternative needs to be found. A global problem is one in which reliable data point you in a direction far removed from the original plan.

Technical problems are ultimately the responsibility of the principal investigators, so keep them informed. They might provide the solution, or refer you to another resource. Sometimes these problems can take forever to fix, so an upper limit should be agreed upon so that long delays will not be an unpleasant surprise to the other participants. Delays can be the source of much resentment among team members but should be considered an unavoidable consequence of research.

Global problems might require more drastic rethinking. The challenge for the investigator is to decide what constitutes a solvable technical glitch and what comprises a serious threat to the overall objectives. Experience is the best guide. If you have handled similar problems in the past, then you are the best judge. If you haven't, locate someone who has. In any case communicate your concerns to all involved parties as early as possible.

What If Things Go Better Than Expected?

How can you use good fortune to your best advantage? Most research triumphs are a blend of good times and bad. When good things happen during the course of your work, you may find yourself ahead of schedule or gaining confidence in the direction of your efforts. If you find yourself ahead of schedule, think ahead and use the extra time to stay ahead.

More often than not there will be subsequent phases of the work for which too little time has been allocated. Start the next step early or spend the time to address future problem areas of the plan. If the nature of the success you have achieved is to eliminate the necessity for some of the future work planned, you may be tempted to skip ahead. Such a change would constitute a significant departure from the original plan, so check with your superiors before proceeding on this altered course.

When Has the Project Been Completed?

A project will end when the basic objectives have been met. This view of the end is comforting in that you have specific objectives and a plan to achieve them, but disconcerting if the objectives change for reasons described above. If changes were controlled, discussed and documented throughout, endpoints should still be easy to identify. This is another reason why it is so important to establish a written consensus for each deviation in the plan.

Was the Project a Success?

If you stuck to your original plan and encountered no problems along the way, you were lucky. If problems required you to adapt your thinking, then real success was achieved. Remember, true failures are rare. The process of conducting research is one of constant evolution. If you have maintained an open mind and based your decisions on the facts uncovered by your work, your efforts were successful.

A Friendly Suggestion

If you are a new investigator or otherwise engaged in research that is new to you, take a lesson from the “old-timers.” It’s not that they have all the answers, it’s just that they know how to ask better questions. They have had numerous opportunities to make their own mistakes, and if they have been successful, it is because they have learned from them.

THE RESEARCH

Are Bad Data a Myth?

Data are the medium of the scientific method, and can neither be good or bad. Data are the answers to the questions we pose, and it is the way we pose these questions that can be good or bad. Data could have intrinsic values: indeterminate, suggestive, or compelling in nature. Poorly posed questions often lead to indeterminate results, while exquisitely framed questions more often lead to compelling data. Therefore the secret to good research is in its design.

What Constitutes a Successful Outcome?

The answer to this question requires another: What are the specific objectives of your work? Must you produce a publication (basic research), a working model (industrial research), a reliable technique (applications research), or a prophetic example (intellectual property development)?

The specifications for success may vary significantly among these outcomes, so it might be worthwhile to verify your objectives with your supervisor or your collaborators.

What Source of Data Would Be Most Compelling?

If the answer isn't apparent, imagine yourself presenting data in front of a group of critical reviewers. What sort of questions or objections would you expect to hear? Answers to this question can be gleaned from seminars on topics similar to yours and from the scientific literature. The data published in peer-reviewed journals have stood up to the test of the review process and have been condensed to the most compelling evidence available to the author. You might also learn that the author applied an unexpected statistical analysis to support their conclusions.

Do You Have the Expertise to Obtain These Types of Data?

Do you have access to the specific equipment, materials, and methods necessary to perform your work? Finding access to one of these elements can provide access to the other, as can a network of friends and colleagues. Your desire for training might inspire someone to loan you the use of their equipment, along with their expertise.

What are your options if the equipment or expertise are unavailable to you? A review of the scientific literature might provide you with an alternative approach. For example, if tech-

nique *A* isn't available, the literature describing the development of that method will undoubtedly discuss techniques *B* and *C* and why they are inferior to technique *A*. Even if you have access to technique *A*, verifying your data via technique *B* or *C* might prove useful.

What Can You Do to Maximize the Reliability of Your Data?

Equipment and Reagents

Is your instrumentation working properly? When was it last checked for accuracy? An inaccurate spectrophotometer or pH meter could affect many aspects of your research. Do you possess all necessary reagents and have you proved their potency?

Have you considered your current and future sample needs? Will you employ statistical sampling in your experimental plans? You might save time, trouble, and money by analyzing your statistical sampling needs at the start of the project instead of returning to an earlier phase of the research to repeat a number of experiments. How will the data be collected, stored, and analyzed? How will statistics be applied, if at all?

Sample Issues

Replicates

A discussion about statistical analysis is beyond this book, but Motulsky (1995) provides practical guidance into the use of statistics in experimental design. Consider the use of statistics when determining the number of required replicates. Otherwise, you might find yourself returning to an earlier phase of your project just to repeat experiments for the purpose of statistical validation.

Quantity

How much material will you require over the short and long terms? Will the source of your material be available in the future, or is it rare and difficult to obtain? Will the physiological or chemical properties of the source change with time? What is the likelihood that the nature of your work will change, introducing new sample demands that require frequent sample preparations?

Should you prepare enough material in one episode to last the duration of your project? Sounds like a sure approach to minimize batch to batch variations, or is it? If the sample requirements make it practical to prepare an extraordinarily large amount of material, what do you know about the storage stability of the

prepared material? Will chemical stabilizers interfere with the research now or in the future? Periodic control assays of material stored over a long term might prove helpful.

If the sample is subject to minimal batch-to-batch variation during preparation, then multiple small samplings may be the most convenient approach, for this provides an additional benefit of providing fresh sample.

If you can verify or control for the long-term stability of your sample, large-scale sample preparations are usually preferred, since most samples reflect the state of their source at the time that they are obtained.

Quality

Generally speaking, samples of high purity require much more starting material, so one approach to controlling demand on sample quantities is to establish the requisite levels of purity for your application. Many assays and experiments have some degree of tolerance for impurities and will work well with samples that are only moderately pure. If you test the usefulness of different sample purities in your research, you might uncover opportunities to reduce the required amount of sample.

Are You on Schedule?

You will likely be asked for precise estimates of when you plan to complete your work, or for time points of certain research milestones. The answers to the previous questions should provide you with the big picture of the research and how the individual parts could affect one another. An accurate sense of the overall timing of the research ahead should follow.

This is also a good point to search your memory, or that of a colleague who has done similar work, to identify potential pitfalls. The goal is to eliminate surprises that tend to get you off schedule.

Which Variables Require Controls?

Consider the converse question: Which variables don't require controls? You might have to switch sample origins, reagents, reagent manufacturers, or instrumentation. As discussed in Chapter 2, "Getting What You Need from a Supplier," suppliers don't always notify the research community of every modification to a commercial product. Even control materials require their own controls. As mentioned above, you'll want to have proof that your large quantity of frozen control material is not degrading with

time. Considering the possible changes that can occur during the course of a research project, it's risky to conclude that there exists any variable that doesn't merit a carefully documented control.

The Roles of Reporting

When Should You Report Your Research Results?

In general, most project leaders and collaborators prefer to be kept informed, good news or bad. When your data are reproducible, discuss it with your research leader or senior colleague. These meetings also provide an opportunity to check that your colleagues' expectations for your research still coincide with your own.

If either party consistently appears surprised or misled, you might want to reevaluate the frequency and form of reporting. As discussed earlier, few research projects proceed exactly as planned, and these changes might require a change in the nature and scope of your reporting.

What Are Your Expectations When You Report Your Data?

Like most of life's endeavors, a research project begins with and is motivated by at least two very human desires. One desire is to uncover the truth no matter the outcome (the noblest case), while a second is to achieve our personal goals (the practical case). Research is not done in a vacuum and inherently contains biases. Consider these conscious and subconscious factors when you and your colleagues interpret data and offer conclusions.

Ideally there will be only one tenable interpretation of the data, but this is a rare outcome. Providing a fair treatment of the various interpretations in the report should lead to a dispassionate discussion that produces a consensus next step if not a conclusion.

What Are Your Options When Someone Attacks Your Data, Interpretations, or Conclusions?

The most common (and very human) initial response is to become defensive, to focus your energy on finding a weakness in your detractor's attack. A more productive route would be to welcome and embrace any contrary opinions. Pay attention to the details; make sure you thoroughly understand every aspect of their criticism. If you can objectively analyze your detractor's comments, the worst that can happen is for your research to be improved. One of the most productive phrases in the human vocabulary is the statement; "Maybe you're right, let's think

about it some more.” Unfortunately, it is also one of the most underutilized.

THE REWARDS

Money is usually not the sole motivator. The practice of science requires much patience, a willingness to take risks, and the ability to wait months or years for the rewards. This requires a special kind of personal and professional commitment. Why did you choose to practice science in the first place? Curiosity and awe in the workings of nature? “Science in the service of knowledge and society” might elicit chuckles from some within and outside the scientific community, and that’s a shame.

Hopefully you will find ways to enjoy the scientific process on a daily level, working to achieve the big things while relishing small accomplishments. Consider the benefit of recognizing and rewarding the achievements of others and you, and by all means, have fun along the way.

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